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# IS 10000-10 (1980): Methods of Tests for Internal Combustion Engines, Part 10: Tests for Smoke Levels, Limits and Corrections for Smoke Levels for Variable Speed Compression Ignition Engines [TED 2: Automotive Primemovers]

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( Reaffirmed 2006 )

*Indian Standard*

# METHODS OF TESTS FOR INTERNAL COMBUSTION ENGINES

## PART X TESTS FOR SMOKE LEVELS, LIMITS AND CORRECTIONS FOR SMOKE LEVELS FOR VARIABLE SPEED COMPRESSION IGNITION ENGINES

**1. Scope** — Specifies tests for exhaust gas opacity, limits and correction factors for exhaust gas opacity for new diesel engines for automotive applications.

### 2. Relationship Between Light Obscuration and Soot Concentration

**2.1** For black smoke, there is a near linear relationship between light obscurations and soot concentration ( gravimetric density g/m$^3$ ). It has been found experimentally that when the exhaust gas opacity is expressed in the gravimetric units ($C$) the relationship between acceptable exhaust gas density and exhaust volume flow ($G$), over the range 40 l/s to 150 l/s, is given by the formula:

$$C\sqrt{G} = \text{Constant}$$

where

$G$ = nominal gas flow for naturally aspirated and for pressure-charged engines in litres per sec;

$G = \dfrac{V \times n}{60}$, $l$/s for two-stroke engines;

$G = \dfrac{V \times n}{120}$, $l$/s for four-stroke engines;

$V$ = total cylinder swept volume in litres;

$n$ = crankshaft speed in rev/min, measured at the occasion of measurement of light absorption coefficient ($k$); and

$k$ = is light absorption coefficient ( m$^{-1}$ ) of an infinitely short column of exhaust gas at atmospheric pressure and at a temperature of 343K.

**2.2** In practice, correlation between light obscuration and soot concentration cannot be determined with sufficient accuracy for the units to be used interchangeably with mean correlation curves, and therefore for the purpose of this standard, exhaust gas opacity is defined and measured by light obscuration smokemeter ( opacimeters ).

### 3. Measurement of Light Absorption Coefficient

**3.1** The measurement of light absorption coefficient shall be made with an opacimeter or an instrument which can be proved to give equivalent results.

**3.2** For the purpose of this standard, the acceptable upper limit of exhaust gas opacity for engines in new condition, run-in in accordance with the manufacturer's recommendations shall be as given in Table 1 read with Fig. 1 in Appendix A.

**3.2.1** For guidance, information on an opacimeter and an interpretation of Table 1 in terms of the readings from this opacimeter are given in Appendix B. The requirements for use of this opacimeter are also included.

**3.3** The limiting exhaust gas opacity, as defined, applies only to measurements taken with the engine running at steady speeds and full load over the speed range from the maximum rated speed down to 45 percent of this speed or 1 000 rev/min, whichever is greater. The limits apply when the engine is operating under the standard reference conditions given in IS : 10000 ( Part II ) - 1980 'Methods of tests for internal combustion engines : Part II Standard reference conditions.' Correction shall be applied to the appropriate opacimeter reading for ambient site conditions different from standard reference conditions using correction factors according to this standard.

Adopted 31 December 1980 © November 1981, BIS Gr 7

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Internal Combustion Engines Sectional Committee, EDC 14; Methods of Test and Code of Practice for IC Engines Subcommittee, EDC 14 : 3 [ Ref : Doc : EDC 14 (3131) ]

**3.4** For engines with multiple exhaust pipes, nominal gas flow, *G* shall be taken as the total exhaust flow and light absorption coefficient, *k* shall be the opacity of the combined flow. If it is not possible to combine the exhaust pipes for exhaust gas opacity measurement, the opacity reading for any individual pipe shall not exceed the limit based on the nominal gas flow of the whole engine.

**3.5** The smoke measurement may also be carried out by using Bosch smokemeters. The correlation between Bosch smoke values, Hartridge smoke values and exhaust gas opacity is given in Fig. 3.

**3.5.1** For guidance, information on the use and maintenance of Bosch smokemeter is given in Appendix C.

## 4. Correction of Exhaust Gas Opacity

**4.1** Correction data exist only for certain proprietory instruments. The light obscuration smokemeter for which correction data is given is the Hartridge opacimeter with an effective exhaust gas column length of approximately 0·43 m and these corrections are given in Fig. 2 for four-stroke naturally aspirated engines. The corrections shall be applied as follows:

Corrected exhaust gas opacity = Observed exhaust gas opacity ± Opacity correction

**4.1.1** For engines other than four-stroke naturally aspirated engines, no correction shall be applied, but if the inlet air density ( ignoring humidity ) is more than 5 percent different from that given by the standard conditions, mention shall be made of it but no values are specified at persent as there is insufficient data for such engines. This will be supplemented at a later stage.

**4.2** When the exhaust gas opacity is less than 20 or greater than 80 Hartridge smoke units, no correction shall be applied, and the observed readings shall be stated. If the corrected exhaust gas opacity is less than 20 or greater than 80 Hartridge smoke units, the corrected exhaust gas opacity shall be stated as 'less than 20' or 'greater than 80' Hartridge smoke units, as appropriate. For an effective exhaust gas column length of 0·43 m, 80 Hartridge smoke units represents an absorption coefficient of 3·75 $m^{-1}$ and 20 Hartridge smoke units a value of 0·52 $m^{-1}$.

**4.3** For test atmospheric conditions outside the limits specified below ( *see also* Fig. 2 ) the correction factor shall be as agreed to between the manufacturer and the purchaser or inspecting authority:

| *Condition* | *Limit Range* |
|---|---|
| Barometric pressure | 710 - 780 mm Hg |
| Air inlet temperature | 278 - 318 K ( 5 — 45°C ) |

### TABLE 1 LIMIT VALUES OF EXHAUST GAS OPACITY APPLICABLE IN THE ENGINE TESTS AT STEADY SPEED

( *Clauses* 3.2, 3.2.1, A-1 and B-1.1 )

| Nominal Flow *G* ( *l*/s ) | Absorption Coefficient *k* ( m−1 ) | Nominal Flow *G* ( *l*/s ) | Absorption Coefficient ( m−1 ) |
|---|---|---|---|
| <42 | 2·00 | 120 | 1·20 |
| 45 | 1·91 | 125 | 1·17 |
| 50 | 1·82 | 130 | 1·15 |
| 55 | 1·75 | 135 | 1·13 |
| 60 | 1·68 | 140 | 1·11 |
| 65 | 1·61 | 145 | 1·09 |
| 70 | 1·56 | 150 | 1·07 |
| 75 | 1·50 | 155 | 1·05 |
| 80 | 1·46 | 160 | 1·04 |
| 85 | 1·41 | 165 | 1·02 |
| 90 | 1·38 | 170 | 1·01 |
| 95 | 1·34 | 175 | 1·00 |
| 100 | 1·31 | 180 | 0·99 |
| 105 | 1·27 | 185 | 0·97 |
| 110 | 1·25 | 190 | 0·96 |
| 115 | 1·22 | | |
| | | 195 | 0·95 |
| | | >200 | 0·93 |

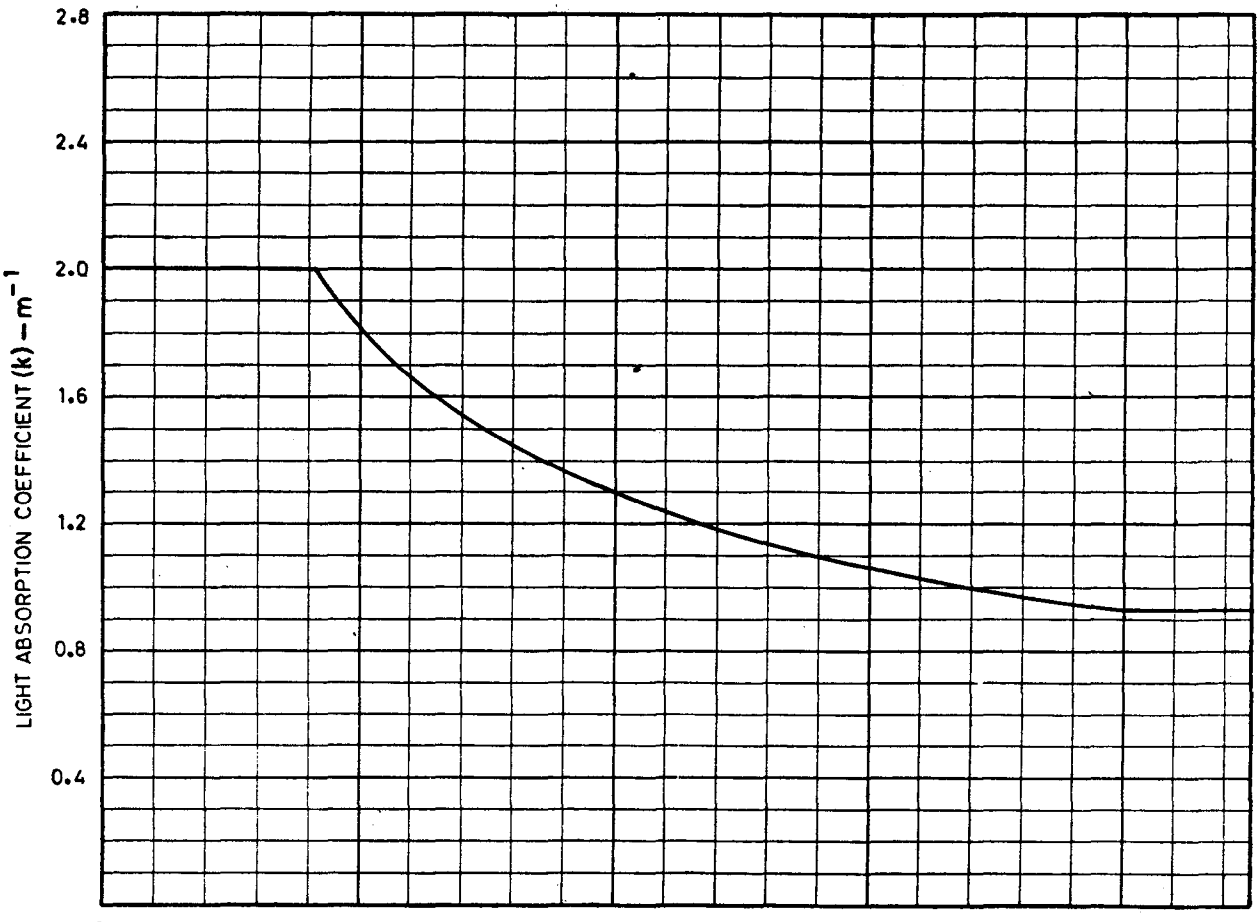

FIG. 1 LIMITING EXHAUST GAS OPACITY FOR ENGINES IN NEW CONDITION

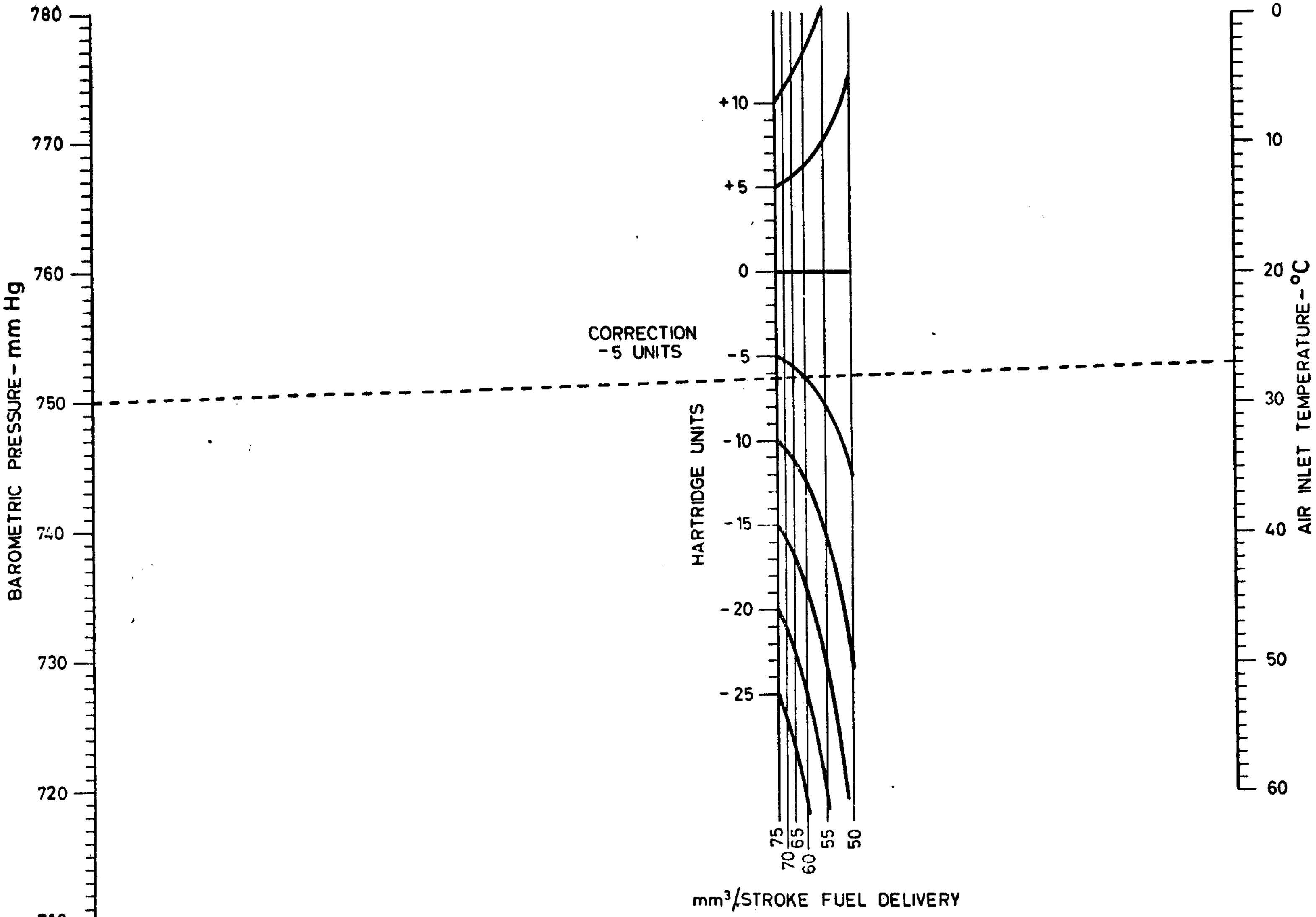

FIG. 2 CORRECTION FOR HARTRIDGE SMOKE ( FOUR - STROKE NATURALLY ASPIRATED ENGINES )

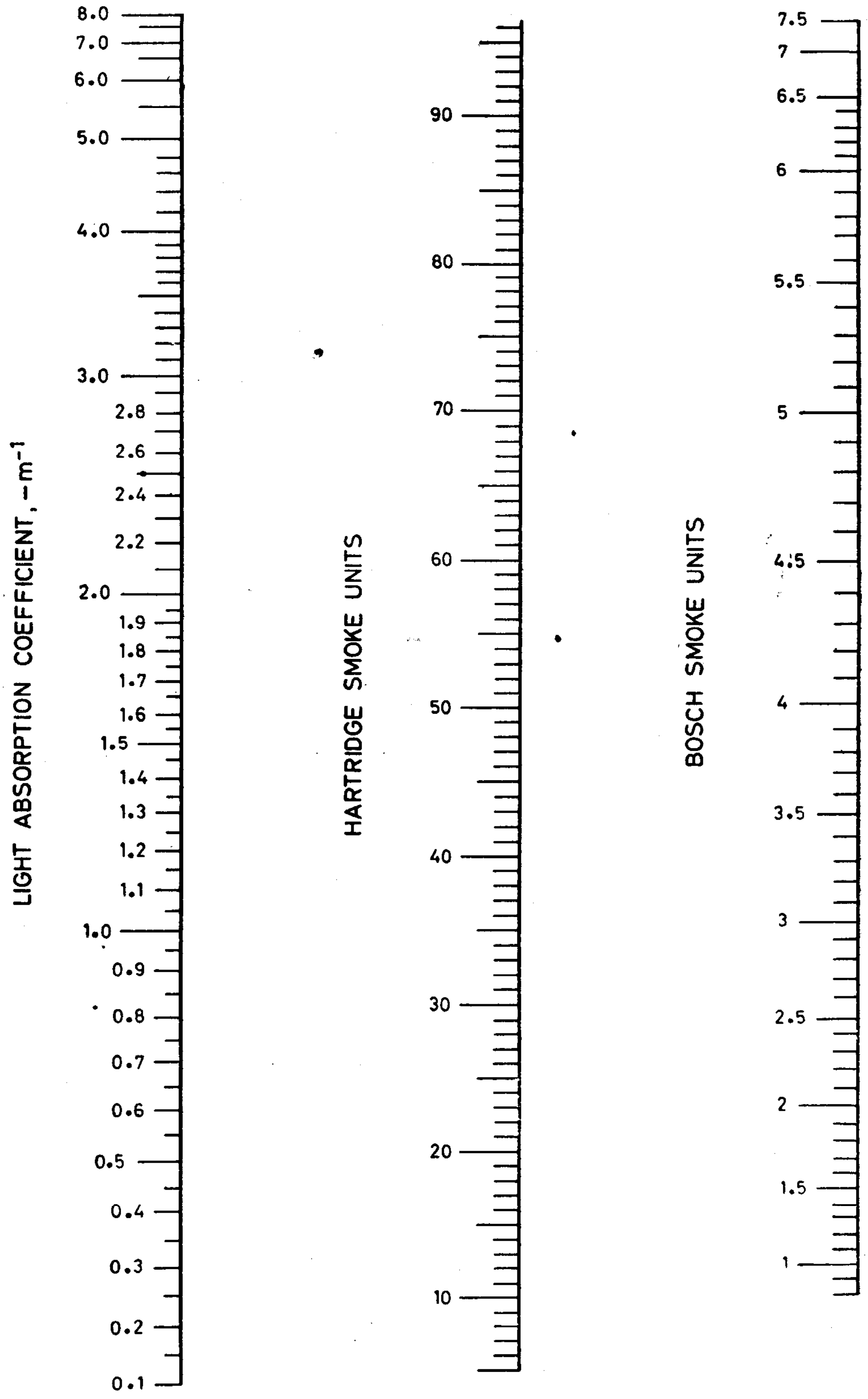

FIG. 3 DIESEL ENGINE EXHAUST SMOKE VALUE CORRELATION CHART

## APPENDIX A

( *Clause* 3.2 )

### LIMIT FOR EXHAUST GAS OPACITY FOR NEW ENGINES

**A-1. Upper Limit for Exhaust Gas Opacity** — Shall be as given in Table 1 read with Fig. 1.

## APPENDIX B

( *Clause* 3.2.1 )

### INFORMATION ON AN OPACIMETER

**B-1. General** — The only practical method available at present for measuring exhaust gas opacity from an engine on the test bed is by using recognized opacimeters. Provided the effective exhaust gas column length $L$ of such meters can be determined, the linear scale $N$ ( 0 to 100 ) of such instruments can be related to the coefficient of absorption $k$ by the following formula:

$$k = \frac{-1}{L} \log_e \left( 1 - \frac{N}{100} \right)$$

where

$L$ = effective length of smoke column in metres, and

$N$ = linear scale reading from 0 to 100.

**B-1.1** For the Hartridge opacimeter, the effective column length has been determined as approximately 0·43 m and the values of Hartridge smoke units corresponding to the coefficients given in Table 1 are given in Table 2.

**TABLE 2 LIMIT VALUES OF TABLE 1 IN TERMS OF HARTRIDGE SMOKE UNITS**

( *Clause* B-1.1 )

**( Based on effective exhaust gas column length of 0·43 m )**

| Nominal Flow l/s | Hartridge Smoke Units | Nominal Flow l/s | Hartridge Smoke Units |
|---|---|---|---|
| <42 | 57·5 | 120 | 40 |
| 45 | 56 | 125 | 39·5 |
| 50 | 54·5 | 130 | 39 |
| 55 | 53 | 135 | 38·5 |
| 60 | 51·5 | 140 | 38 |
| 65 | 50 | 145 | 37·5 |
| 70 | 49 | 150 | 37 |
| 75 | 47·5 | 155 | 36·5 |
| 80 | 46·5 | 160 | 36 |
| 85 | 45·5 | 165 | 35·5 |
| 90 | 44·5 | 170 | 35 |
| 95 | 43·5 | 175 | 35 |
| 100 | 43 | 180 | 34·5 |
| 105 | 42 | 185 | 34 |
| 110 | 41·5 | 190 | 33·5 |
| 115 | 41 | 195 | 33·5 |
| | | >200 | 33 |

Note — Because of inherent inaccuracies in the method of measurement a tolerance of ± 5 Hartridge smoke units shall be allowed on each meter reading.

**B-2. Instructions for Use of Hartridge Smokemeters on Test Beds**

**B-2.1** *Installation*

**B-2.1.1** The smokemeter probe shall consist of a tube with an open end facing upstream on the centreline of the exhaust pipe, or extension pipe, if required. The cross sectional area of the probe shall be not less than 5 percent of that of the exhaust pipe.

**B-2.1.2** The probe shall be situated at a point where the distribution of smoke is approximately uniform. To achieve this the probe shall be placed as far downstream of the exhaust mainfold as possible or if necessary, in an extension pipe so that the open end of the probe is situated in a straight portion with at least 6 *D* in length upstream of the sampling point and 3 *D* downstream, *D* being diameter of exhaust pipe. If an extension pipe is used, air shall not be allowed to enter at the joint. The probe should preferably be fitted in the exhaust pipe at a point such that the static pressure in the exhaust pipe measured adjacent to the opening of the probe is not more than 50 mm of water, but in any case the increase in exhaust back pressure due to the probe and any associated fittings shall not exceed 75 mm of water.

**B-2.1.3** Air expansion tank of compact design and about 7 litres capacity shall be inserted in the sample line as close to the probe as possible.

**B-2.1.4** A butterfly valve or other means of increasing the sampling pressure may be placed in the exhaust pipe at least 3 *D* downstream from the sampling probe.

**B-2.1.5** The connecting pipes between the probe, expansion tank and smokemeter shall be as short as possible and have at least 22 mm bore. The pipe shall be inclined upwards from the sampling probe to the smokemeter and sharp bends where soot can accumulate shall be avoided.

**B-2.1.6** If not already fitted to the smokemeter, a bypass valve shall be inserted upstream of the smokemeter and a manometer fitted to the water trap.

**B-2.1.7** The clean air inlet shall be unobstructed except as may be required in **B-2.4.5**.

**B-2.1.8** Only one smokemeter waste exit shall be used and this shall be fitted with the manufacturers standard waste pipe of equivalent pressure drop. The waste pipe shall be so positioned that smoke from it will not be drawn back into the clean air inlet to the meter.

**B-2.2** *Electrical Supply* — The smokemeter shall be connected to a suitable stable 12 V supply. For short tests, a single 12 V battery in good condition and well charged may be used. For longer tests, two batteries shall be used, one for the blower circuit and the other for the bulb. For test bed work, a mains-operated power pack with stabilized voltage shall be used.

**B-2.3** *Checks on the Meter* — Before use each day, it shall be verified that there is no water in the water trap.

**B-2.4** *Preparations for Measurement*

**B-2.4.1** The smokemeter shall be switched on for at least 4 minutes piror to use, to stabilze the meter electrically. During this 4-minute period, gas shall be passed through the bypass to stabilize the system thermally.

**B-2.4.2** With the control knob on 'zero check' position, the zero setting knob until the meter reads zero ( 0 Hartridge smoke units ).

**B-2.4.3** Move the control knob to the 'smoke check' position and check that the meter still reads zero ( 0 Hartridge smoke units ). A positive reading may indicate a need to service the bypass valve.

**B-2.4.4** Insert the standard density screen and check that the meter reading is within ± 2 units of that stamped on the screen holder. If the reading is outside these limits, clean and check the smokemeter ( if necessary refer to manufacturers' manual ).

**B-2.4.5** With the scavenge air blower operating and bypass valve in the position for smoke bypassing the smokemeter, check that the pressure in the water trap is between 10 mm and 15 mm water. If the pressure is too low then either the fan is faulty or the fan voltage is too low. If the pressure is too high, fix a restricting plate across the fresh air inlet to reduce the pressure to within the stated limits.

**B-2.4.6** With the engine running, operate the bypass valve to pass smoke into the smokemeter and ensure that the pressure in the water trap is between 50 mm and 75 mm water. If the pressure is outside of these limits adjust the butterfly valve in the exhaust pipe. These limits of sample pressure shall be maintained at all engine speeds.

**B-2.4.7** No precise information for sample temperature is given but it is preferred that a temperature sensor is installed upstream of the bypass valve so as to indicate sample temperature irrespective of whether smoke is entering the water trap or not. It is suggested that temperature at this point should be between 403 K and 503 K ( 130 and 230°C ) for full load smoke reading.

**B-2.5** *Procedure for Measurement*

**B-2.5.1** With smoke bypassing the smokemeter check that the meter is still at zero with the control knob in both the ' zero check ' position and the ' smoke check ' position. Adjust, if necessary.

**B-2.5.2** Operate the bypass valve and allow smoke to enter the meter. Set the meter control to ' smoke check '. Observe the smoke reading for a period of approximately 10 seconds, averaging any fluctuations.

**B-2.5.3** Return bypass to original position and recheck on the ' zero check ' position so that the meter returns to zero.

**B-2.5.4** Repeat **B-2.5.2** and **B-2.5.3**.

**B-2.5.5** Between readings at different conditions the bypass valve shall be positioned so that the smoke bypasses the smokemeter.

**B-2.6** *Maintenance*

**B-2.6.1** For smokemeters in constant use, the smoke sampling tube shall be brushed out and the photoelectric cell and lamp wiped clean of soot at least once a week or whenever it is impossible to zero the unit. Meters which are used occasionally shall be thoroughly cleaned after each use.

**B-2.6.2** Batteries used for smokemeters shall be recharged as often as is necessary to ensure that ' on-load ' voltage is maintained between 11 V and 13 V.

**B-2.6.3** Difficulty in obtaining the zero check may be due to corrosion at the electrical connections at the lamp tags and at the connections at the rear of the smokemeter. Where a new lamp bulb has been fitted, ensure that the filament is not masked by its support.

## APPENDIX C

( *Clause* 3.5.1 )

## INFORMATION ON BOSCH SMOKEMETER

### C-1. Purpose

**C-1.1** The Bosch smokemeter is a portable, accurate and reliable testing instrument to measure the exhaust smoke of diesel engines. The readings from the evaluating instrument can easily be reproduced Black diesel smoke results from incomplete oxidiation of fuel oil molecules during the combustion process caused by a localized lack of air or a localized excess of fuel in the combustion chamber. The engine, fuel or fuel injection system may be the cause for this.

**C-1.2** Diesel fumes with a high soot content hinder the visibility and cause annoyance to public. However, diesel engine with increasing smoke shows a considerable increase in output. This fact is often used by engine user illegally to his own advantage.

**C-1.3** The Bosch smokemeter serves as a testing device for exhaust gases to keep diesel smoke within reasonable limits, with, as far as possible, the least reduction in engine output under all operating conditions. Tests can be made on a test bench.

### C-2. Description

**C-2.1** In the Bosch smokemeter, a sampling pump draws off a certain amount of exhaust gas from exhaust pipe of engine and then sucks it through a filter paper disc. The filter paper disc, in turn, darkness during this process and thus gives the measure of soot content of the exhaust gases. The evaluating instrument is then used to take a reading off the darkened disc photoelectrically.

**C-2.2** *Accessory Case with Sampling Pump* — The accessory case contains:

a) Sampling pump,
b) Gas sampling probe,
c) Pneumatic tripping device,
d) Clamp, and
e) Filter paper discs of 45 mm dia.

**C-2.3** *Evaluating Instrument*

**C-2.3.1** The evaluating instrument is constructed as a small, handy steel case containing:

a) Microammeter,
b) Potentiometer for zero adjustment,
c) Leak-proof cells 1·5 V, and
d) Photo-cell adaptor.

**C-2.3.2** The photocell adaptor has a light source which throws a beam on to the darkened filter paper disc after the adaptor has been placed against the disc. The unabsorbed portion of light is then reflected from the darkened disc on to an annular photocell, generating a photocell current which is in turn indicated by the microammeter.

**C-2.3.3** The instrument scale is divided into 0 to 10 degrees of darkening. Number 0 corresponds to an absolutely white disc, while number 10 corresponds to a disc which absorbs all the light ( when the instrument is switched off it indicates 0 as well ).

**C-3. Operation** — To make sure that there are no soot particles of previous tests in the sampling probe or hose which might influence the measuring results, hose and sampling probe shall be blown out with compressed air before the test. A check should be made by pumping fresh air through a filter disc. The disc must not darken.

**C-3.1** *Testing on Test Bench* — The sampling pump is fastened to the last, console or to a tripod with the clamp provided for this so that 550 mm hose rises gradually. This ensures also during repeated tests, that condensation on the filter paper disc will be avoided, this would otherwise prevent even impregnation of soot on the filter paper.

**C-3.1.1** Test bench exhaust pipes are often under back pressure near the engine. In such a case, it is recommended to provide a stop valve right next to the sampling probe, to stop the filter being darkened before the actual test. ( It may be more convenient to insert a venturi between two flanges of the exhaust pipe so that the gas sample can be drawn off at sub-atmospheric pressure ). It is generally more advantageous to conduct the test under sub-atmospheric pressure to eliminate pre-test filter coloration.

**C-3.1.2** If test is to be carried out at excessively high pressure, it is advisable to attach to main exhaust pipe a bypass of 10 mm dia, over a chock of, say, 2 mm dia, and to affix the sampling probe to a T-piece of this bypass taking care to avoid condensation and air infiltration ( *see* Fig. 4 ).

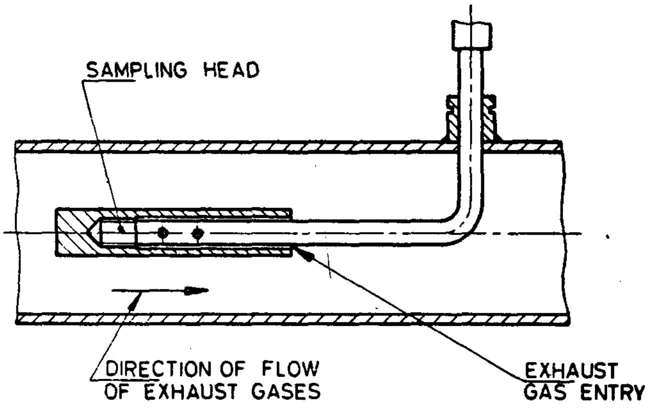

FIG. 4 TEST ARRANGEMENT AT HIGH PRESSURE

**C-3.1.3** The sampling probe is inserted into the exhaust pipe in such a manner that it is, as far as possible, not located next to a bend, since bends cause scatter due to deposits or turbulence.

**C-3.1.4** The sampling probe may need alteration to suit local conditions when fitted in test bench exhausts. In such cases, however, do not alter the sampling head with smoke intake, nor its position in the exhaust pipe.

**C-3.1.5** Tests with low soot deposits, when following tests with high soot content, are apt to be distorted if exhaust pressure is in excess of atmospheric pressure because of soot deposit at the valve and in the hose. In this case, a second test is recommended, after having properly blown out suction hose and sampling probe. To eliminate the influence of the volume between filter and exhaust, which could in the extreme be filled entirely with either air or gas when exhaust pressure is above atmospheric, do not move the pump piston into operating position until after the filter disc has been inserted. This precaution is not necessary when sub-atmospheric pressure exists both at the sampling probe and the exhaust.

**C-3.2** *Testing Procedure*

**C-3.2.1** Attach sampling punp with clamp to the exhaust pipe. Sufficient ground clearance can be obtained for test bed by fitting the clamp laterally or at a slant. Insert sampling probe into exhaust pipe and fasten with the spring clip.

**C-3.2.2** Unscrew cap nut and insert a filter paper disc retainer. Then close the pump.

**C-3.2.3** Push the pump piston until it engages, if it has not already been done. This automatically cocks the spring which, when pneumatically released, causes the suction stroke.

**C-3.2.4** Place the flexible release hose in such a way that the rubber ball can be operated without difficulty, for example, from the driving seat during road tests.

**C-3.2.5** Release the suction stroke at the desired time by squeezing the rubber ball tightly. Be careful not to compress the rubber ball only momentarily, but over a period of several seconds, thus ensuring that the pump piston can travel right to its final position.

**C-3.2.6** Conduct tests on the engine at full load, at full throttle. The following points should be observed during this test:

a) Engine shall have normal operating temperature. Cooling water temperature shall be at least 333 K 60°C;

b) The engine shall be run at full load at full throttle,

c) The engine shall be run for at least 5 seconds at maximum speed and full load in order to obtain constant exhaust conditions. Release suction stroke of sampling pump by tightly squeesing rubber ball for some at least 5 seconds, and

d) In cases of doubt it is recommended to repeat the test. As the values can be reproduced, the same values should be obtained with the same conditions.

**C-3.2.7** Unscrew plug and take outfilter. Evaluate the darkened filter disk by using the evaluating instrument. When using several accessory cases with sampling pumps only one evaluating instrument is required.

**C-3.3** *Evaluation of Darkened Filter Paper Discs* — The evaluation should not be made in a place exposed to glaring sunlight in order to prevent adjustment errors.

**C-3.3.1** The block setting of the evaluating instrument can be controlled with the aid of an adjustment disc. A greater accuracy is achieveable in the region of limit values of degrees of darkening by using the disc. Deviations due to instrument tolerance, age or displacement of bulb position are eliminated by the use of adjustment disc.

**C-3.3.2** The adjustment disc consists of black paper with precisely stamped holes.

**C-3.3.3** Adjustment is effected as follows:

a) When the instrument is switched off, it should indicate 10 degrees of darkening. If necessary, adjust the indicator with the zero adjusting screw in the instrument glass,

b) Switch on instrument,

c) Lay about 10 clean paper filter discs on top of each other with an adjustment disc on top, centre the photo cell adapter and adjust the potentiometer knob so that the instrument indicates 5 degrees of darkening exactly,

d) Now measure the sooted filter disc. Again lay about 10 new filter discs underneath, and

e) The adjustment disc must not be touched in the measuring area, dirtied or damaged in order to prevent false adjustment. It is thus necessary to replace the adjustment disc frequently.

**C-4. Maintenance**

**C-4.1** If during operation of the evaluating instrument with the built-in dry-cell battery the microammeter during adjustment can no longer be adjusted to 0, even when the rheostat-knob is in its extreme left position, the batteries are flat and must be replaced.

**C-4.2** After changing the bulb in the photo cell adaptor it may be possible that even with new batteries the pointer of the instrument cannot be adjusted to 0 with the rheostat. In this case, the compensating resistor at the rear of the front plate has to be regulated correspondingly. To do so, remove front plate.

**C-4.3** Before changing the battery, as well as before the first operation of the instrument, and after replacing the adaptor bulb, always turn the rheostat to its extreme right position (to protect the 3·8 V bulb from excessive voltage.)

**C-4.4** Always place the protective cover over adaptor to shield the lightsensitive layer of the photocell when not in use. Do not expose the adaptor to intense sunlight without protective cover (overloading of microammeter), and protect the adaptor from temperatures above 80°C. The evaluating instrument should not be roughly handled or jolted. To check microammeter for correct functioning, turn instrument to ON and cover the adaptor slowly and gradually with a dark sheet. The indicator should move evenly from 0 to 10. Any jerking motion or temporary stopping of the pointer shows that the instrument is damaged.

**C-4.5** The sampling pump must be checked from time to time for leaks.

**C-4.6** *Testing the Sampling Pump* — In place of the filter disc, a similar piece of plastic approximately 0·1 mm thick should be fitted and should be clamped tight. The outward movement of the piston must last at least 30 seconds after triggering if the pump is not leaking.

**C-4.7** *Testing the Sampling Pump with Exhaust Probe and Connection Hose* — In place of the filter disc, fit a similar sized piece of plastic approximately 0·1 mm thick, which has a hole approximately 8—10 mm in diameter, at the centre. Tighten the disc.

**C-4.7.1** Screw the probe head off the exhaust probe and cover the end of the tube with a tight fitting rubber cap.

**C-4.7.2** The outward movement of the piston must last at least 30 seconds after triggering if the pump, including probe and connection hose are not leaking.

**C-4.7.3** After sometime, when the sampling pump piston operates slowly, the pump must be stripped and cleaned. Use good quality grease for lubricating pump cylinder.

**C-4.7.4** Do not oil or grease the rubber diaphragm of the pneumatic tripping device.

**Note** — The microammeter and adaptor are adjusted jointly and are, consequently, not separately exchangeable.

## EXPLANATORY NOTE

The testing and performance of constant speed and variable speed internal combustion engines was earlier covered by the following Indian Standards:

IS : 1600-1960 Code for type testing of constant speed internal combustion engines for general purposes

IS : 1601-1960 Performance of constant speed internal combustion engines for general purposes

IS : 1602-1960 Code for type testing of variable speed internal combustion engines for automotive purposes

IS : 1603-1960 Performance of variable speed internal combustion engines for automotive purposes

These standards were originally issued in the year 1960. As a result of implementation of the standards by the manufacturers of engines and testing laboratories, as also the operation of ISI Certification Marking Scheme, the standards have now been extensively revised.

While IS : 1600 and IS : 1602 covered the codes for type testing of constant and variable speed engines respectively, the performance requirements of such engines were covered by IS : 1601 and IS : 1603, respectively. These standards are replaced by two sets of standards, one set covers the methods of testing of engines and the other covers the specification and performance requirements of both constant speed and variable speed engines.

The standard covering methods of test is being published in following 12 parts ( each part covering a particular test method or information related to methods of tests ):

IS : 10000 Methods of tests for internal combustion engines:
- Part I Glossary of terms relating to test methods
- Part II Standard reference conditions
- Part III Measurement for testing—units and limits of accuracy
- Part IV Declarations of power, efficiency, fuel consumption and lubricating oil consumption
- Part V Preparation for tests and measurements for wear
- Part VI Recording of test results
- Part VII Governing tests for constant speed engines and selection of engines for use with electrical generators
- Part VIII Performance tests
- Part IX Endurance tests
- Part X Tests for smoke levels, limits and corrections for smoke levels for variable speed engines
- Part XI Information required with enquiry or order and information supplied by the manufacturer with the engine
- Part XII Test certificates

This standard will be complementary to specifications for performance requirements of different types of engines covered by following standards:

IS : 10001 Specification for performance requirements for constant speed compression ignition ( diesel ) engines for general purposes ( up to 20 kW )

IS : 10002 Specification for performance requirements for constant speed compression ignition ( diesel ) engines for general purposes ( above 20 kW )

IS : 10003 Specification for performance requirements for variable speed compression ignition ( diesel ) engines for automotive purposes

IS : 10004 Specification for performance requirements for variable speed spark ignition engines for automotive purposes

Spark ignition engines for sprayers and similar applications have been covered by IS : 7347-1974 'Specification for performance requirements of small size spark ignition engines for sprayers '.

Two-stroke spark ignition engines for automotive applications which were earlier covered by IS : 1603 will be covered by a separate specification.

The revised methods of tests covered by IS : 10000 have been aligned with the current international practices in the field of internal combustion engines. These parts are in general agreement with the following ISO standards issued by the International Organization for Standardization:

ISO 3046/I-1975 Reciprocating internal combustion engines — Performance: Part I Standard reference conditions and declarations of power, fuel consumption and lubricating oil consumption

ISO 3046/II-1977 Reciprocating internal combustion engines — Performance : Part II Test methods

ISO 3046/III-1979 Reciprocating internal combustion engines — Performance : Part III Test measurements

ISO 2710-1978 Reciprocating internal combustion engines — Vocabulary

In IS : 1600 to IS : 1603 did not cover the exhaust smoke measurement or acceptable limits for the exhaust smoke which is a nuisance to road user as well as causes obscuration of light, thereby reducing the visibility of driver.

While revising these standards, the committee took cognizance of this fact and laid down the exhaust gas opacity limits covered by this standard. This standard gives information on use and maintenance of an existing opacimeter and also provides information on use and maintenance of Bosch smokemeter which is used extensively throughout the world. A chart of correlation between the light absorption coefficient ( measured by opacimeter ), Hartridge smoke valves and Bosch smoke valves is also included for understanding of the engine manufacturers. The limit values of exhaust smoke as laid down are expected to be met by all the vehicular diesel engine manufacturers in the country.

In the preparation of this standard assistance has also been derived from EEC Council Directive 72/306/EEC dated 2 August 1972, issued by the commission of the European Communities with the view that vehicles and engines manufactured in India meet the emission levels laid down in the above EEC Directive.

IS : 10000 ( Part I to Part XII ) and IS : 10001, IS : 10002, IS : 10003 and IS : 10004 collectively supersede IS : 1600. IS : 1601, IS : 1602 and IS : 1603.

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